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AUTHOR Hayashi, Toshihiro; Yano, Yoneo
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ABSTRACT

In learning the Japanese language, kanji idiom learning is as important as kanji (Chinese characters) learning. A kanji idiom intelligent computer assisted instructional (ICAI) system called JUGAME was developed. It can handle approximately 3,000 kanji idioms and has a puzzle game environment within a learning environment using Open Software Foundation (OSF)/Motif graphic user interface. In this environment, it is the goal of the game for students to find all kanji idioms hidden in the puzzle by combining puzzle elements (kanji). Although it is generally said to be difficult for foreigners to learn kanji idioms, they can be learned through playing the puzzle game without loss of learner motivation. Moreover, JUGAME does not prepare the puzzle patterns in advance. According to the teaching strategy, JUGAME generates an adaptive puzzle pattern focusing on the knowledge level of the student. JUGAME has been implemented on SONY EWS NWS-1750. Concepts are illustrated in four figures. Contains seven references. (Author/MSE)

JUGAME: Game Style ICAI System for Kanji Idiom Learning

Toshihiro Hayashi and Yoneo Yano
The University of Tokushima
2-1, Minamijosanjima, Tokushima 770 Japan
E-Mail: hayashi@is.tokushima-u.ac.jp

Abstract: In learning the Japanese language, kanji idiom learning is as important as kanji(Chinese characters) learning. We have developed a kanji idiom learning ICAI System called JUGAME. It can handle approximately 3,000 kanji idioms and has a puzzle game environment within a learning environment using OSF/Motif graphic user interface. In this environment, it is the goal of the game for student to find all kanji idioms hidden in the puzzle by combining puzzle elements(kanji). Although it is generally said to be difficult for the foreigners to learn kanji idioms, they can learn kanji idioms through playing the puzzle game without losing their motivation. Moreover, JUGAME does not prepare the puzzle patterns in advance. According to the teaching strategy, JUGAME generates an adaptive puzzle pattern focusing on the knowledge level of the student. We have implemented JUGAME on SONY EWS NWS-1750.

Recently, the number of foreigners who are learning the Japanese language has in creased. Kanji learning is one of the most difficult parts of learning the Japanese language for foreigners in Japan, and they need a good educational environment for kanji learning. For this social need, many electronic dictionaries(Nakajima, 1988; Hayashi, & Yano, 1991; Bhatia, 1992; Walters, Fahy, Nakamura, & Reid, 1992) and kanji learning CAI applications (Yamasaki, Yamamoto, & Inokuchi, 1990; Hayashi, & Yano. 1993) have been developed. We have developed a kanji idiom learning ICAI system with a puzzle game environment called JUGAME(Yano, Miyoshi, & Hayashi, 1993) under the guideline of environmental ICAI system and it consists of a domain knowledge base for kanji idioms, a learning environment, a puzzle generator(teaching control module) and an advisor(Fig. 1). The educational aim of JUGAME is for foreigner to learn kanji idioms and their structure, meanings, pronunciations and the related idioms. In addition, the instructional domain of JUGAME is made up of kanji idioms constructed using only two kanji.

JUGAME provides the student with a kanji puzzle game as a learning environment. In this environment, the student tries to construct kanji idioms from a combination of puzzle elements(kanji) and s/he can learn kanji idioms themselves through the puzzle game. Moreover, the student can learn about the constructed kanji idioms from a dictionary function of JUGAME. The patterns of the kanji puzzles are not prepared in advance but JUGAME automatically generates a kanji puzzle. The hidden kanji idioms are appropriate for the knowledge level of the student because the teaching control module selects them based on the teaching strategy. In addition, the advisor function helps the student avoid hitting a learning plateaus in the learning environment, but this paper omits its detail (Please refer to the paper(Yano, Miyoshi, & Hayashi, 1993) about advisor function).

Domain Knowledge Base

Knowledge Representation of Kanji Idiom

We have classified kanji idiom knowledge into the kanji idiom structure, the kanji attributes and the relational words. We call kanji idiom structure, "SIW"(Structure of Idiomatic Words), kanji idiom attributes, "UIW"(Usage of Idiomatic Words) and relational words, "RIW"(Relation between Idiomatic

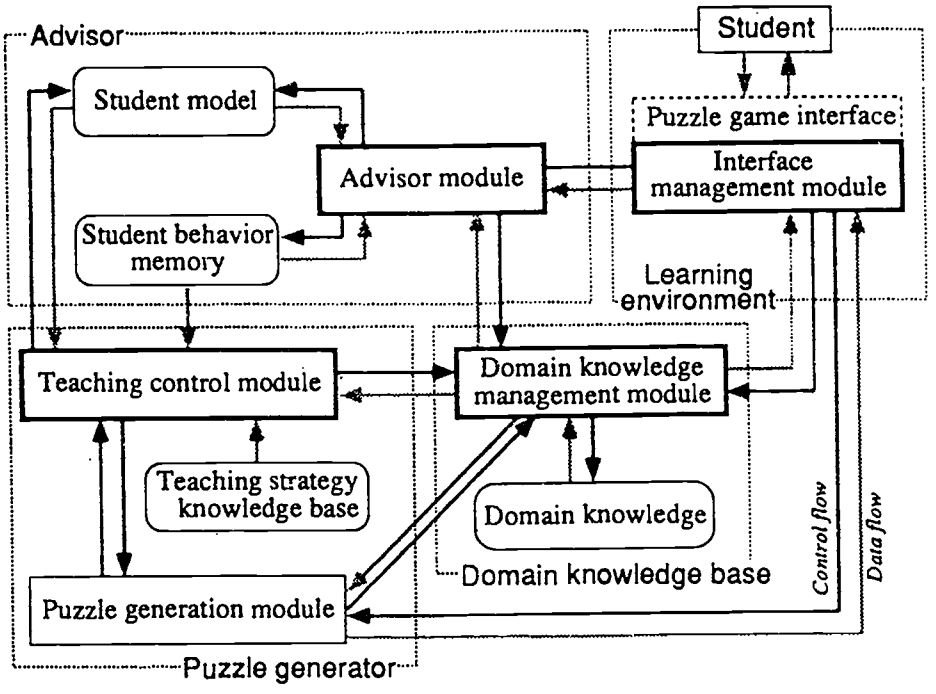

Figure 1 System Configuration

Words). SIW puts emphasis on the relationship between a kanji idiom and its kanji components. SIW represents the kanji components, their meanings, and their pronunciations. In addition, SIW represents the relationship between the two kanji components. UIW puts emphasis on the attributes of a kanji idiom. UIW consists of the meanings, the pronunciation and so on of the kanji idiom. RIW puts emphasis on the relational idioms, such as homonym, synonym and antonym, of a kanji idiom. We do not represent RIW explicitly because RIW is inferred from the attributes of kanji idioms in most cases.

Table 1 Triplet Representation of Kanji Idiom

	Triplet representation	*Example*
SIW	(<idiom>, CONSTRUCTION, <kanji>)	(牛乳, CONSTRUCTION, 牛) (牛乳, CONSTRUCTION, 乳)
	(<idiom>, <kanji>, <meaning of kanji>)	(牛乳, 牛, cow), (牛乳, 乳, milk)
UIW	(<idiom>, READING, <reading>)	(牛乳, READING, gyuunyuu)
	(<idiom>, MEANING, <meaning>)	(牛乳, MEANING, cow's milk)
	(<idiom>, CONCEPTION, <conception>)	(牛乳, CONCEPTION, drink)

Implementation of the Knowledge Base

For implementation of the knowledge base for kanji idioms on a computer, the kanji idiom knowledge is represented by triplets Triplets consist of an entity, an attribute and a value, formalized as (e, a, v) = (entity, attribute, value). Attributes refers entities to values. Any triplet can be used as search conditions in the knowledge base module. The elements e, a, v of a triplet can have '*' as a meta-character. '*'

matches with all strings. For example, $(E, A, *)$ matches with all triplets of which the entity is E and the attribute is A. We call these searches "asterisk searches". We represent kanji idioms' data in triplet format. Table 1 shows an example of the triplet representation of "牛乳."

Searching of Kanji Idiom Knowledge

In the knowledge base, SIW and UIW are searched by asterisk searches but RIW cannot be searched the same way because the kanji idioms do not link directly to their relational kanji idioms. Therefore, JUGAME has some searching procedures to find the relational kanji idioms. With regard to RIW search, for example, a synonym search finds some synonyms using the combination of the asterisk searches. For example, if the search condition is 以外, then JUGAME finds (以外, READING, igai) using an asterisk search with (以外, READING, *). Then JUGAME finds (意外, READING, igai) using an asterisk search with (*, READING, igai). In this way, JUGAME can find the synonyms.

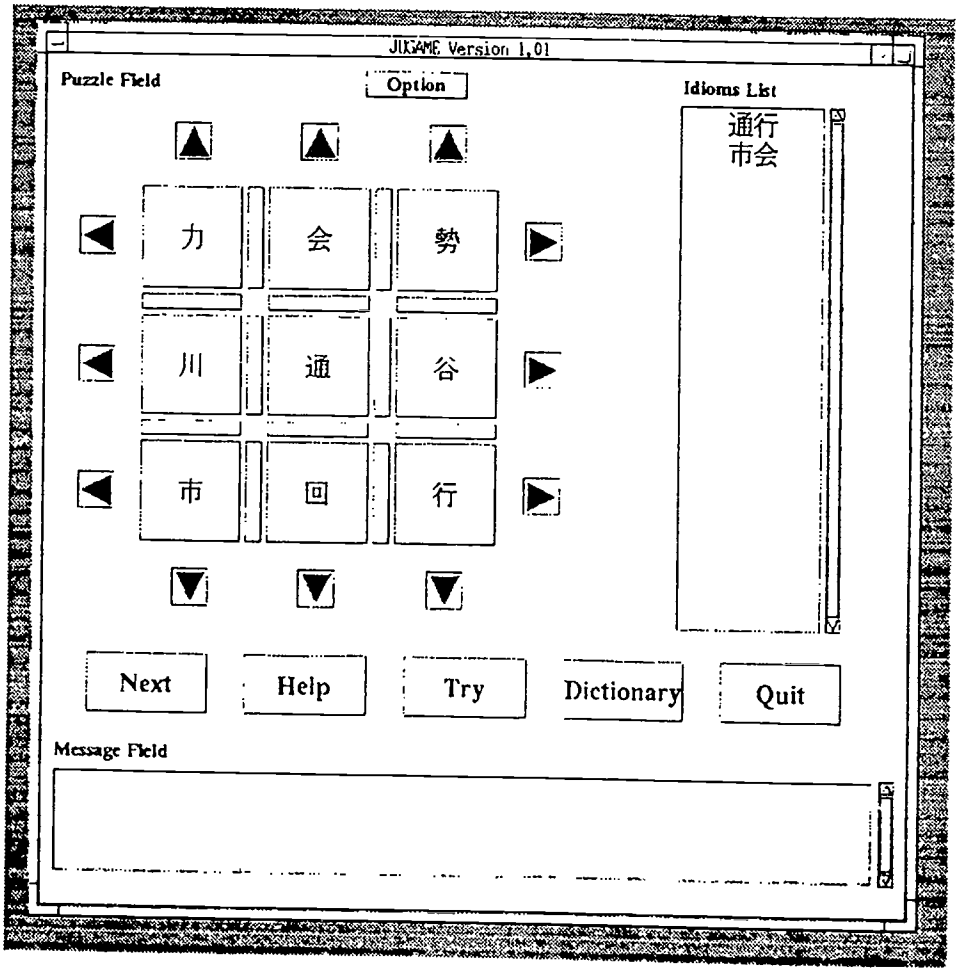

Figure 2 Learning Environment of JUGAME

Learning Environment

JUGAME gives an appropriate learning environment for students who have already learned several kanji. In the learning environment, the students can learn the following: (1) The structure of kanji idioms; (2) The attributes, such as meaning and pronunciation, of kanji idioms; and (3) The relational idioms, such

as synonyms, of kanji idioms. The student can learn the above knowledge indirectly, while s/he solves the kanji idiom puzzles in the learning environment. We think that playing the kanji puzzle game will motivate the student into learning new kanji idioms.

Configuration of the Learning Environment

Fig. 2 shows the learning environment. The learning environment consists of a puzzle field, a kanji idiom field, a message field and puzzle operation buttons.

JUGAME generates kanji puzzle patterns automatically. The kanji puzzle consists of nine kanji placed in 3 by 3 matrix. There are nine buttons called shift buttons around the matrix. The student can perform some of the operations of each row and each column of the kanji puzzle by clicking on a shift button. The student can rotate a row of three kanji to the right or to the left by clicking on a shift button. The student can also move a kanji up or down by a similar column operation.

There are twelve buttons called check buttons between each adjoined kanji. If a student thinks this seems to be a kanji idiom focusing on a pair of two kanji after some row and column operations, s/he can choose the pair by clicking on the check button between the two kanji. The two kanji change color highlight this indication. The student can also choose other pairs of kanji this way. After some of the above operations, the student can check whether the kanji pair becomes a kanji idiom or not by clicking on the try button. After clicking on the try button, JUGAME searches the kanji idiom constructed by the kanji pair. If JUGAME can find the kanji idiom, it shows and stores the kanji idiom in the kanji idiom field. On the other hand, if JUGAME cannot find the kanji idiom, it prints a comment such as, "No kanji idiom is constructed by this kanji pair" in the message field. If the student can find no kanji idiom in the kanji puzzle, the student can learn some unknown kanji idioms in the kanji puzzle by clicking on the help button. The student can construct kanji idioms through easy these button operations.

Illustrated Play of Puzzle Game

The student can learn kanji idioms by going through the above operations. Fig. 3 shows an example of the kanji puzzle operation. Example A shows the construction process of kanji idiom 人権. Example B shows the other construction process of the kanji idiom 人権. In addition, it happens that 達人 is constructed at the same time in example B.

Puzzle Generator

Selection of Puzzle Element

The student is allowed to learn freely in an environmental CAI system. If the learning control by the system is implicit, it does not prevent her/him from learning freely. We adopt the implicit teaching strategy for JUGAME. When JUGAME generates a puzzle, it can control student's action implicitly. JUGAME has three teaching processes: (1) the basic knowledge teaching process; (2) the knowledge stability diagnosis process; and (3) the relational knowledge teaching process. The basic knowledge teaching process is to teach kanji idioms themselves, the pronunciations, the meanings and so on. If the student can construct a kanji idiom on the puzzle game, JUGAME assumes that either the student knows the kanji idiom, or it is unknown to her/him and the student has guessed. If the student did not construct a kanji idiom from puzzle, it is continuously adopted as a puzzle element in the following puzzles. The knowledge stability diagnosis process is to diagnose whether a kanji idiom which is passed from process (1) is stabilized knowledge or not. Based on a hypnosis that *a student can use stabilized knowledge for problem solving even if it has been long time since s/he learned of the knowledge*, this process is executed over a long interval. If the student constructs the kanji idiom again in this process, JUGAME assumes that the kanji idiom is stabilized knowledge. If the student cannot construct the idiom again JUGAME assumes the student guessed and the idiom is sent back to process (1). The relational knowledge teaching process is to teach some relational knowledge of the stabilized kanji idioms. In this process, the elements of the puzzle are relational kanji idioms. Although there are many types of relational kanji idioms, this process selects the proper types and adopts some kanji idioms of these types as puzzle elements.

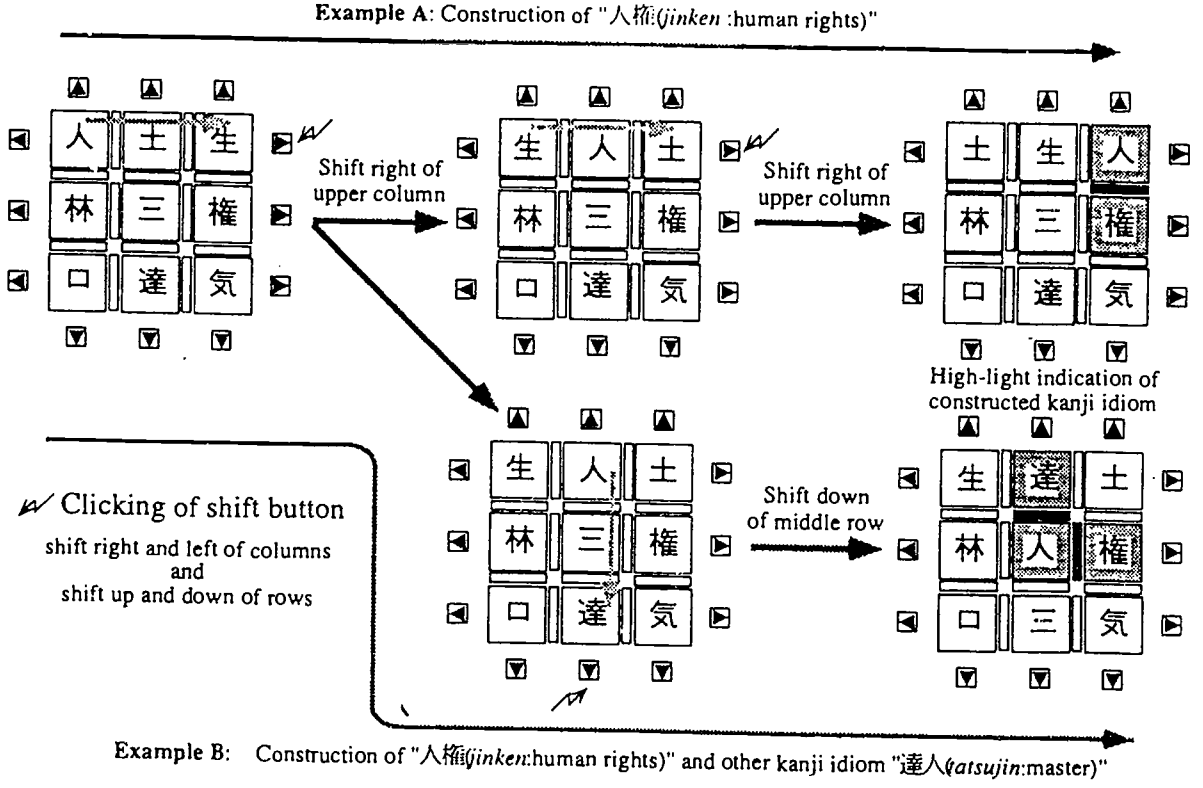

Figure 3 Illustration of Game Progression

Parallel Execution of Teaching Process

In ITSs a process for teaching knowledge cannot run until the previous process for teaching other knowledge has finished. On the other hand, JUGAME has the potential to teach many kanji idioms during one puzzle game. Using this feature, JUGAME can execute different processes for teaching many idioms at the same time. For example, JUGAME can execute the basic knowledge teaching process for idiom A, the knowledge stability diagnosis process for idiom B and the relational knowledge teaching process for idioms C and D during one puzzle game. By the parallel execution of these three processes, JUGAME can teach many kanji idioms effectively. For the implementation of the processes, we adopt multiple agents as respective teaching processes. The agents adjust each request by their message passing and select the elements for the new puzzle. Fig. 4 shows the teaching processes and the respective agents.

Puzzle Generation

JUGAME generates the kanji puzzle automatically using the following processes: First it selects four or less kanji idioms based on the teaching strategy; Then it separates each kanji idiom into two kanji and gathers the kanji into a kanji list.; Then it deletes overlapped kanji from the kanji list and adjusts the kanji list to have nine kanji by adding some random kanji into the kanji list; Then it picks out all kanji idioms constructed by the kanji pairs in the kanji list, and stores the kanji idioms into an idiom list; It generates a kanji puzzle which consists of the nine kanji and checks whether the kanji idiom is already constructed or not in the puzzle using the idiom list. If it finds the constructed idiom, then it performs the previous process again. If it cannot find the kanji idiom, then it performs the next process. Finally, it puts the generated puzzle in the puzzle field. For example, in the case of Fig. 4, JUGAME selects four kanji idioms such as "人権", "人気", "人生", and "人口" based on the teaching at first. These kanji idioms contain '人'. Next, it extracts '人', '権', '気', '生' and '口' from the four kanji idioms and store the five kanji into a kanji list. Then, it adds '林', '土', '二' and '達' into the kanji list. Finally, it generates a

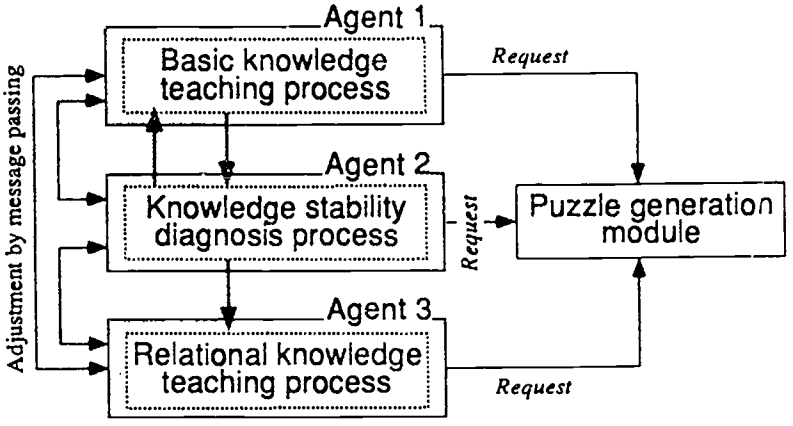

Figure 4 Teaching Processes and Their Agents

kanji puzzle pattern which includes the nine kanji.

Conclusion

In this paper, we described an environmental ICAI system called JUGAME which has a puzzle game environment. In this environment a student tries to solve a puzzle by constructing kanji idioms using the puzzle elements(kanji). The student's actions lead her/him to learn kanji idioms. We think that JUGAME gives a new and motivated learning environment for foreigners to learn kanji idioms. Moreover, JUGAME can control the generation of puzzle patterns implicitly using the teaching control module. This module can select appropriate kanji idioms hidden in the puzzle by referring to her/his knowledge stability.

We have developed JUGAME using C language and OSF/Motif GUI library (a part of JUGAME is coded by Xlib level programming) on SONY EWS NWS-1750. The knowledge base of JUGAME stores 2,826 kanji idioms and they are represented by approximately 35,000 triplets. In spite of many triplets, JUGAME can search through information and generate appropriate puzzle patterns quickly.

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